Workflow Optimization Using Python Programming, a Tool Kit for Every Geoscientist

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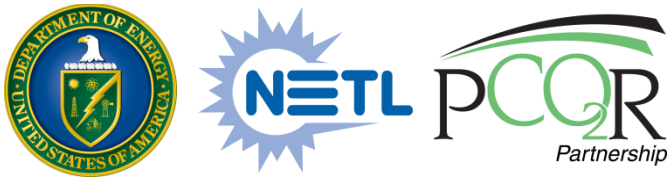
Jason Braunberger

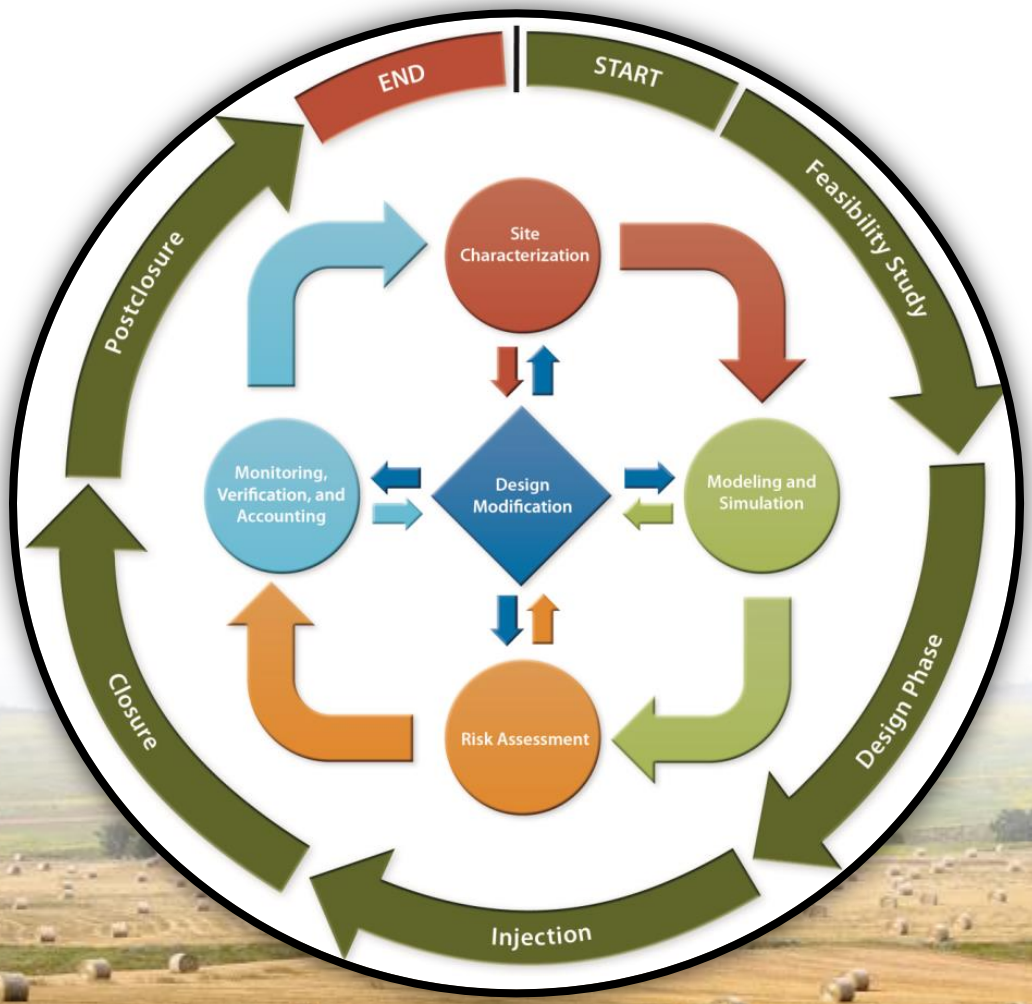


Outline

- Plains CO_2 Reduction Partnership (PCOR)
- Workflow Optimization with Python scripting
  - Integration between software, algorithms, and scripting
    - ♦ Problem #1 – Spatially visualizing complex simulation results
      - Solution – Plume mapping workflow
      - Other applications
    - ♦ Problem #2 – Well spacing optimization
      - Solution – Well placement workflow
      - Other applications
- Summary and future applications

PCOR Partnership

Integrative Approach for MVA



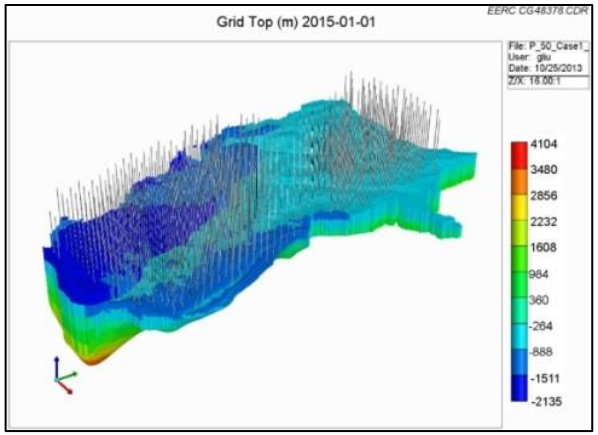
"Focused on site characterization, modeling and simulation, and risk assessment to guide MVA strategy"

Workflow Optimization with Python

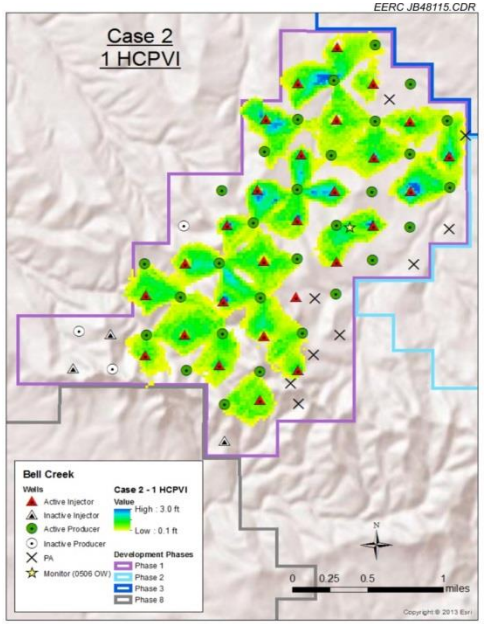
COMPUTER MODELLING GROUP LTD.

Petrel
Shared earth—critical insight

python



Arc GIS
ESRI



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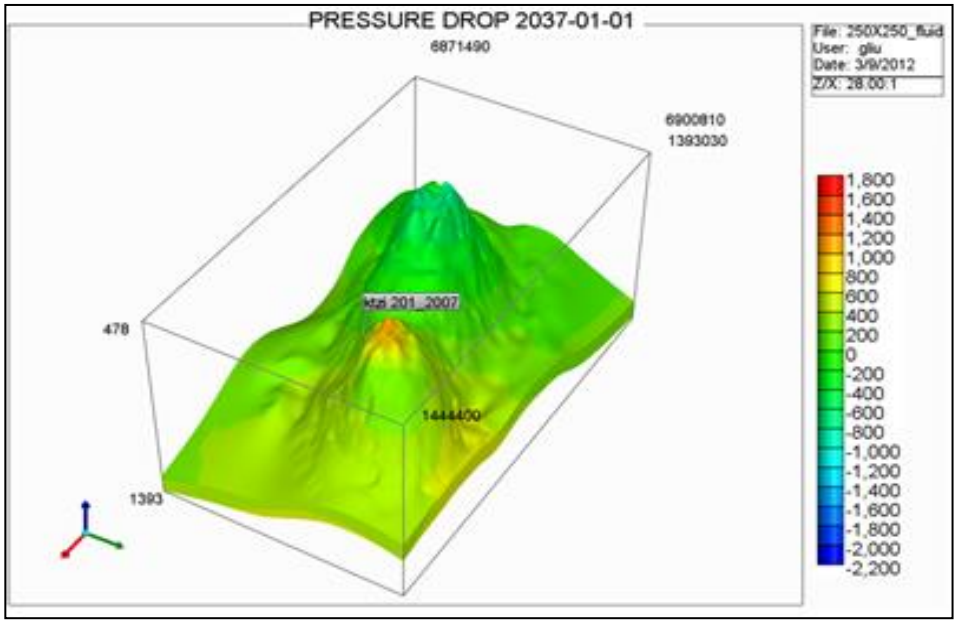
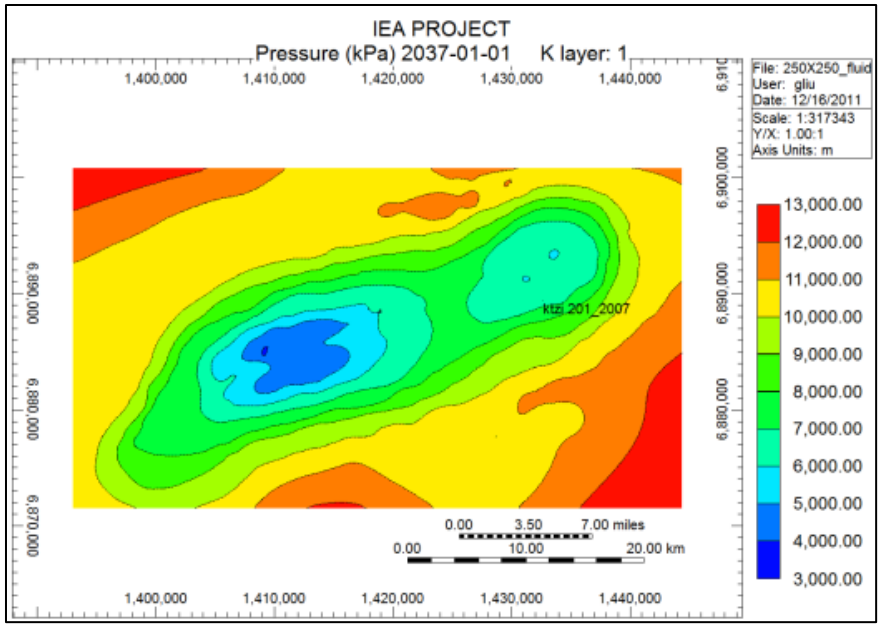
Problem #1
Spatial Data Representation

- Difficult to visualize 3-D simulation results in CMG
  - Spatial coordinates are relative (I, J, K)
  - Calculate total map for property of choice
    - ♦ CMG mapping visualization has minimal colors and cannot add contextual geographic features.

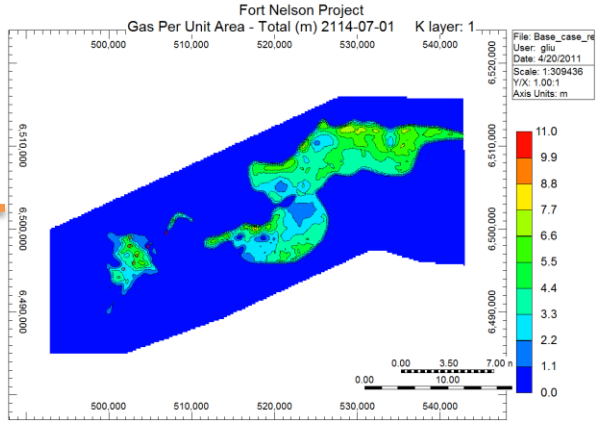


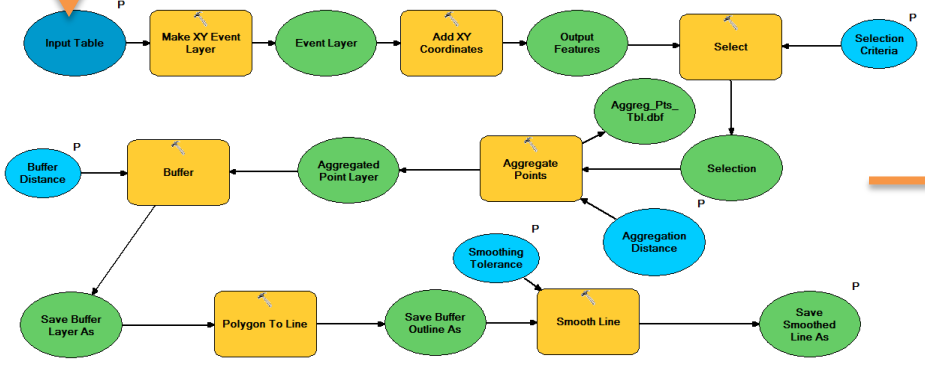


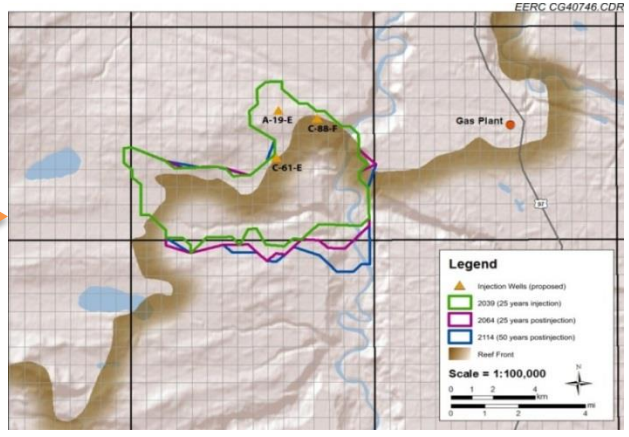
Solution #1
Plume Mapping Workflow

- CMG property exports (ex. GPUA) are not natively read into ArcGIS.
  - Reformat the data using script to a Comma delimited XYZ file.
  - Use Python and XYZ data to quickly create a map using GUI.

Table containing spatial coordinates (X, Y) for gas per unit area as represented by the centroid of each cell

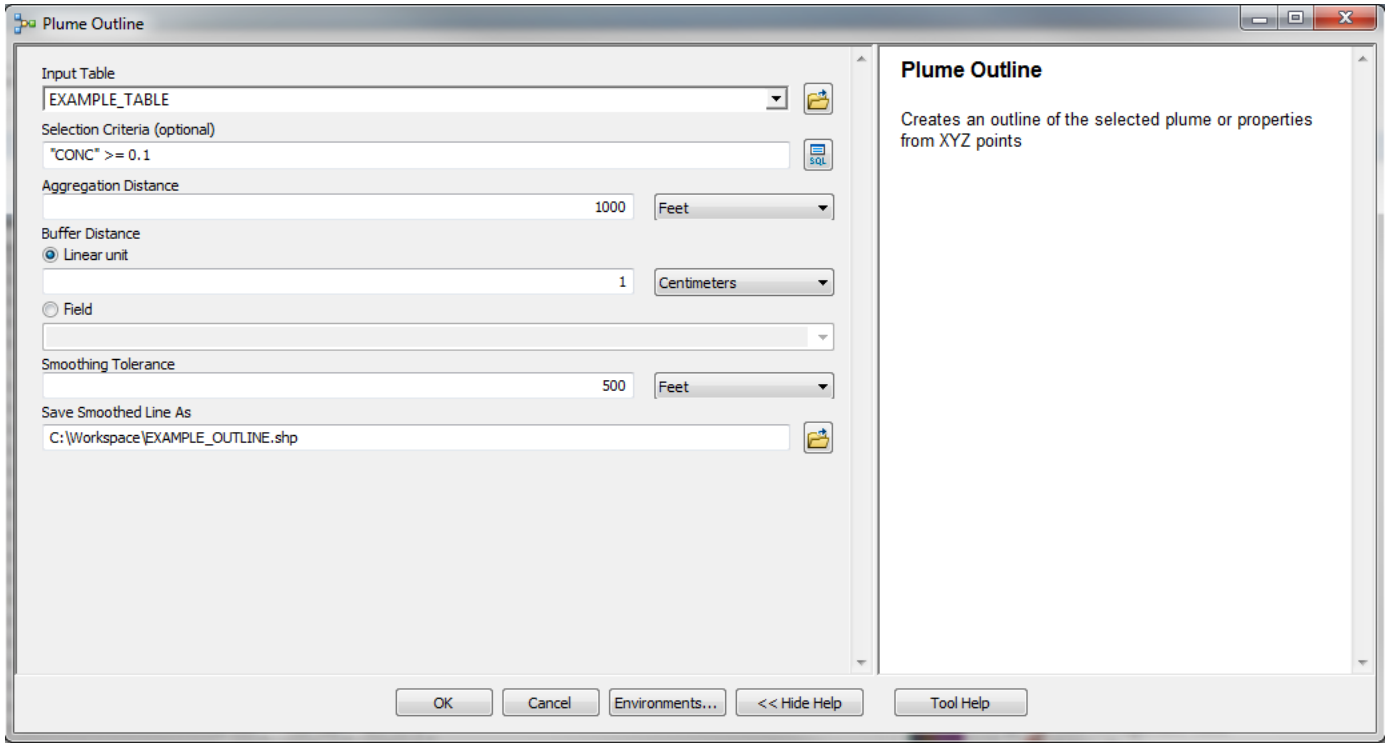






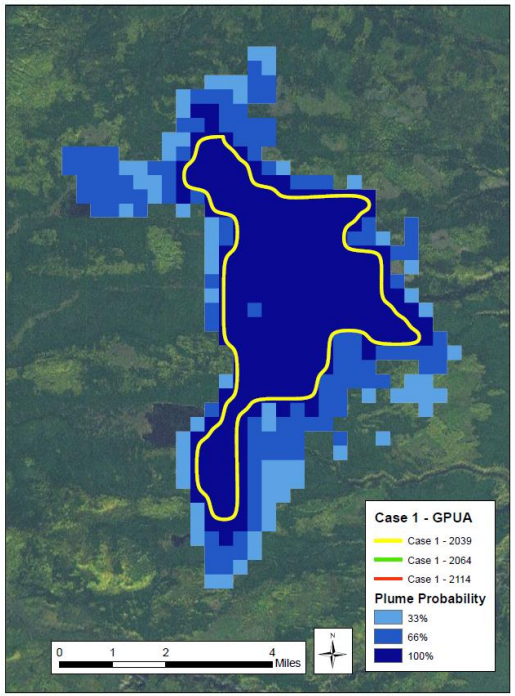
Plume Mapping Tool

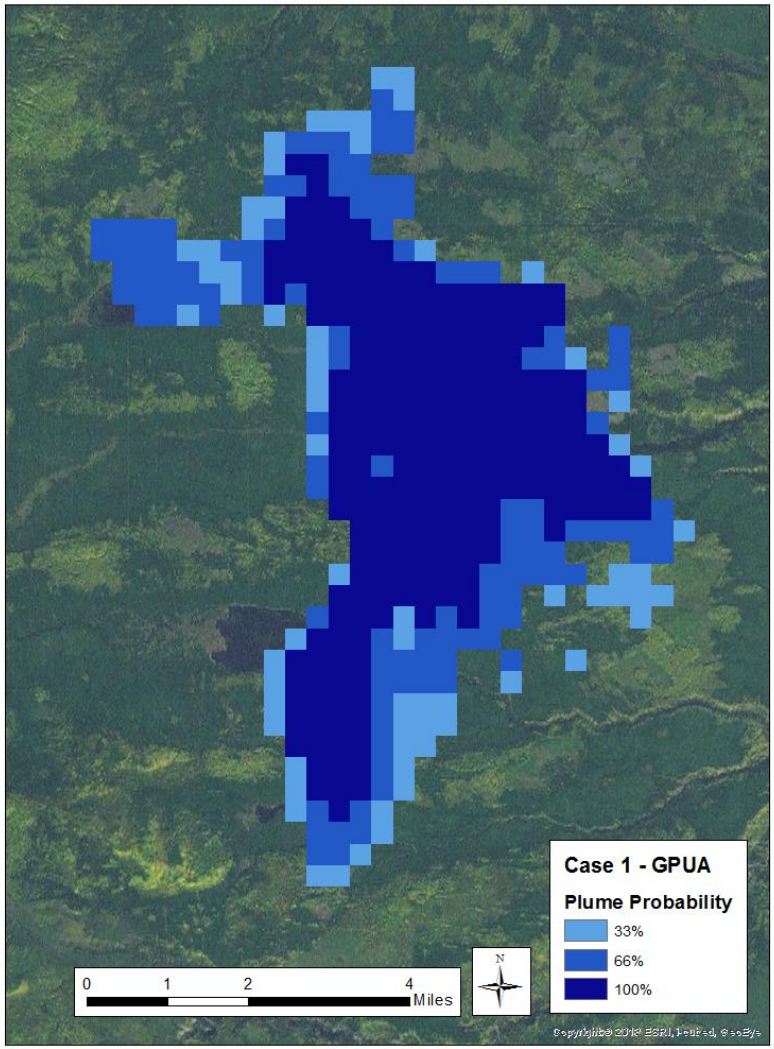
- Utilize ModelBuilder to optimize the workflow.
- Approximately 30 minutes to create each map.
- Toolbox can be shared and imported into ArcMap, allowing use among other users.



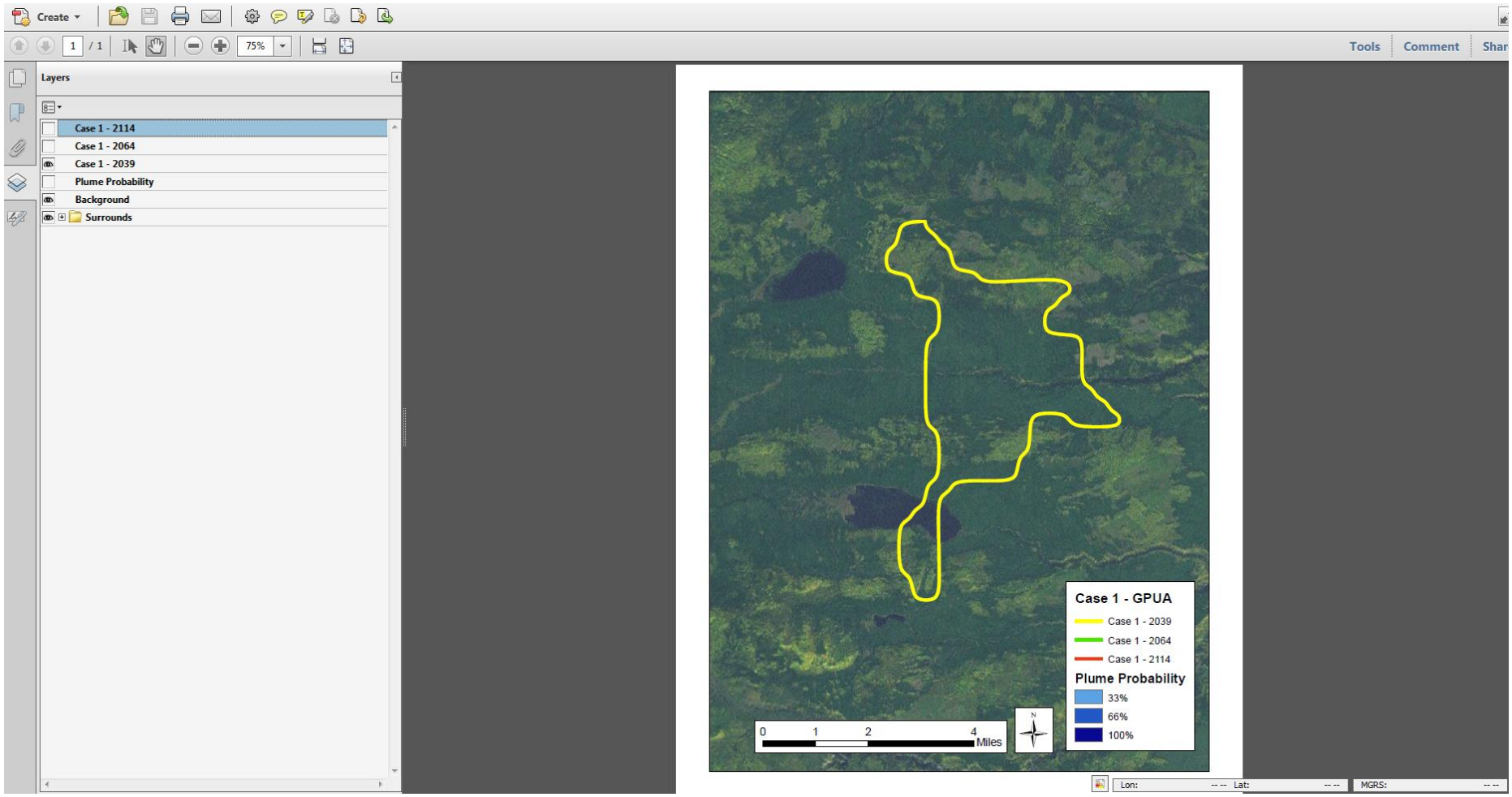
Other Applications

- Probability maps
- Fluid saturation maps
- Various risk assessments maps
- Interactive PDFs





Interactive PDF



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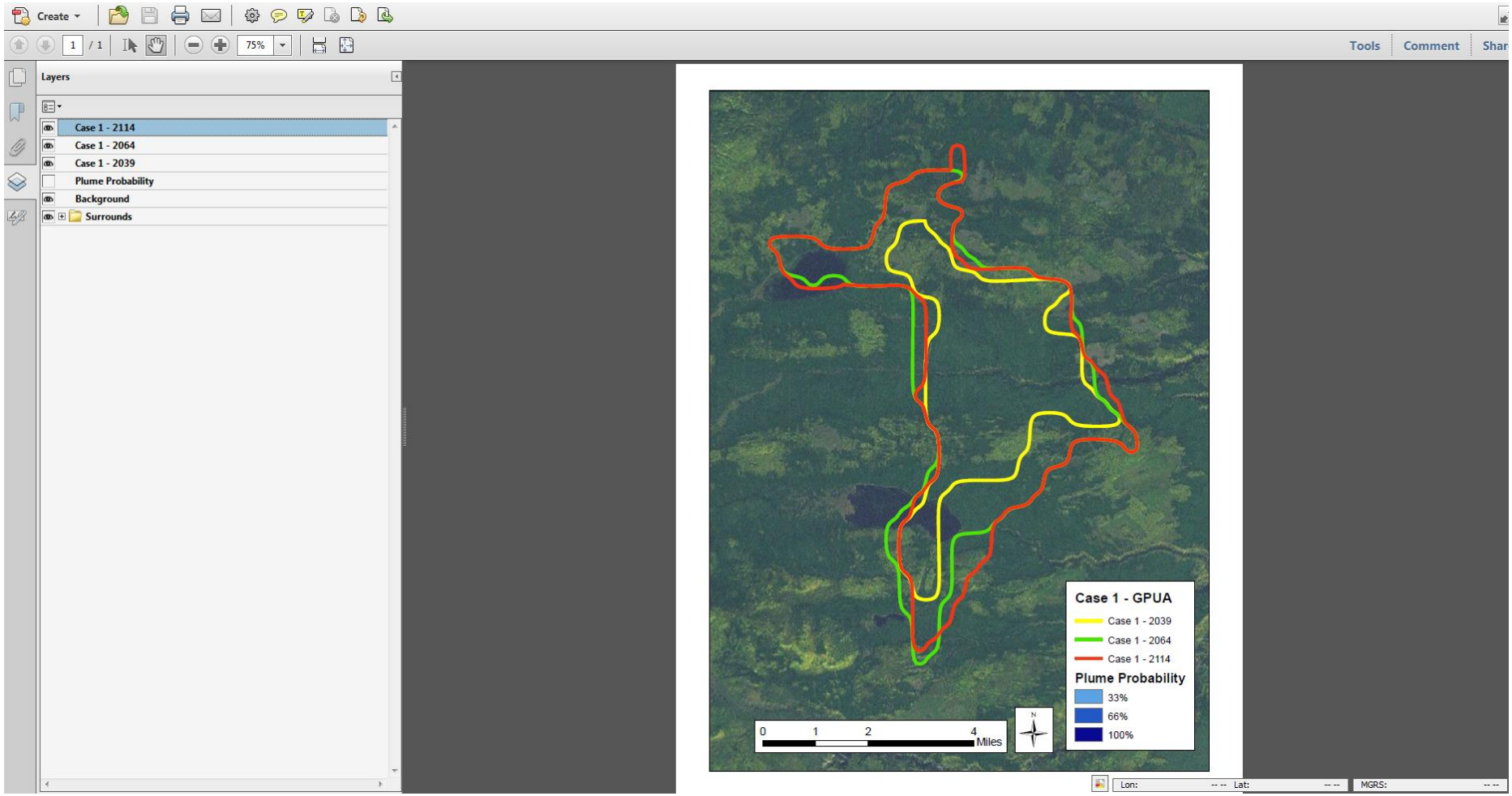
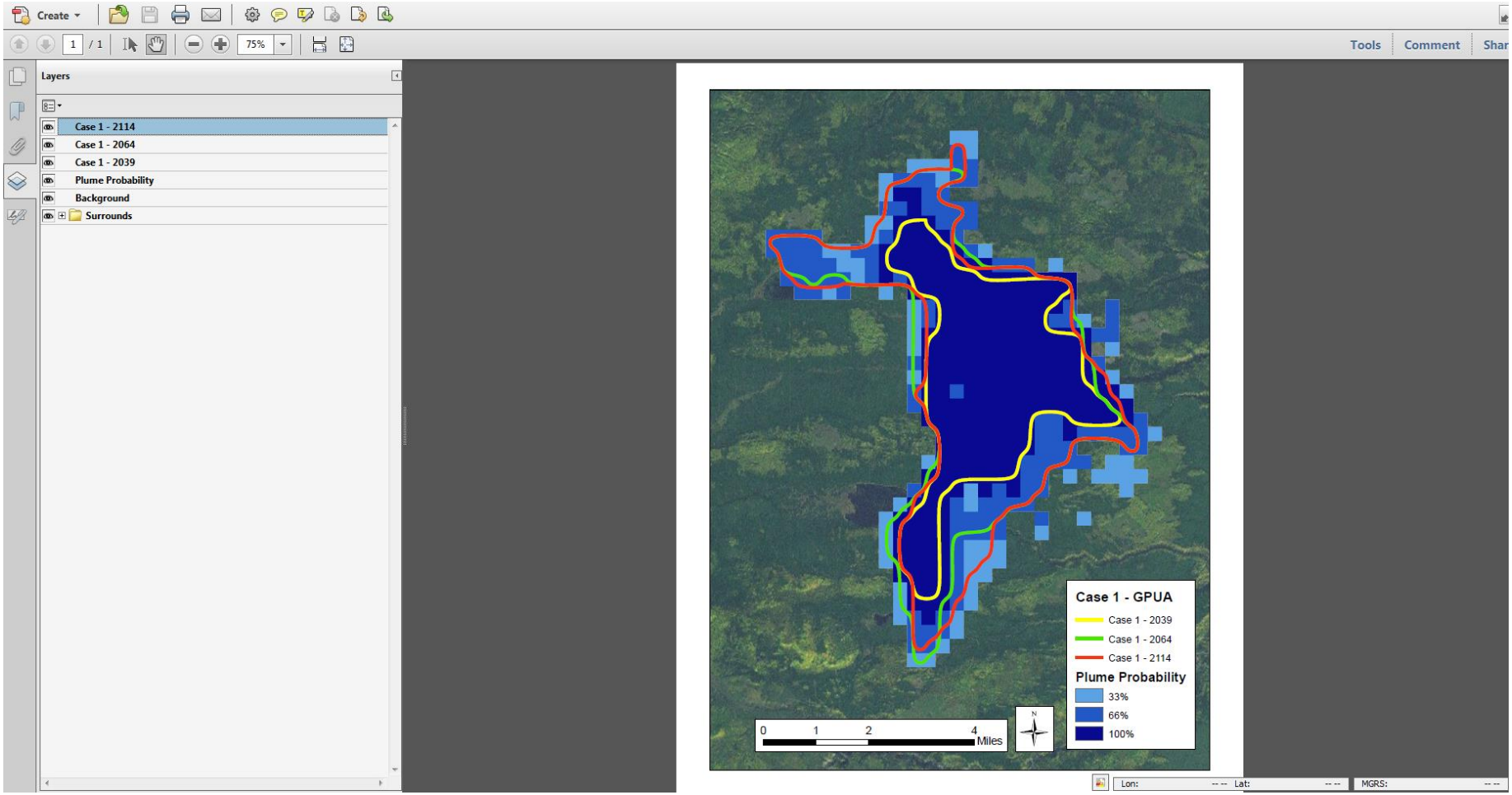
Interactive PDF cont



Interactive PDF cont



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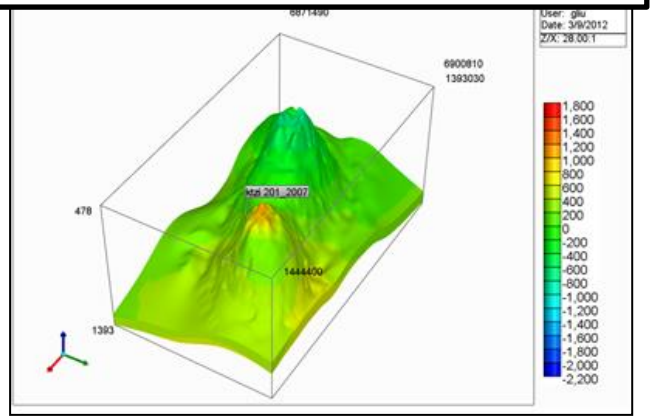
Problem #2
Well Spacing Optimization

- Develop basin for CO_2 storage:
  - Place hundreds of wells for CO_2 injection in a basin sized model.
    - ♦ Manual process is time consuming.
  - Use multiple constraints to place these wells.
    - ♦ Transmissivity, bottom hole pressure, depth, reservoir properties.

- Other uses for field development:
  - Economic forecasting before development begins
  - Reduce uncertainty
  - Decision making

Solution #2
Well Placement Workflow

Export CMG Properties (X,Y,Z)



Spatial Join in ArcGIS

INPUT TABLE

ID	NUM	CHAR
1	10	A
2	15	B
3	20	C
4	25	D
5	30	E
6	35	F

+

JOIN TABLE

ID	NUM	COLOR
1	5	blue
2	10	green
3	15	yellow
4	20	red
5	30	black
6	35	grey

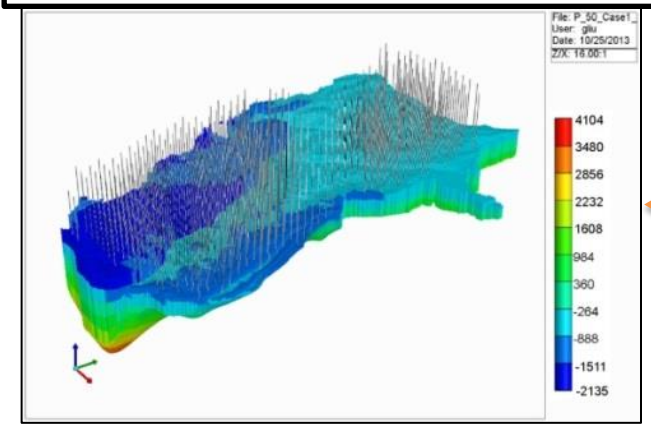
SPATIAL JOIN

=

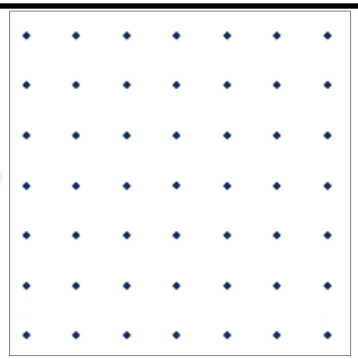
OUTPUT TABLE

ID	NUM	CHAR	COLOR
1	10	A	green
2	15	B	yellow
3	20	C	red
4	25	D	
5	30	E	black
6	35	F	grey

Import Well Locations to CMG



Well Placement Algorithm



```
Enter maximum X value (CMG)
599
Enter maximum Y value (CMG)
755
Injectivity per well?
100000
```

Enter Model Parameters and desired Injectivity into Python script

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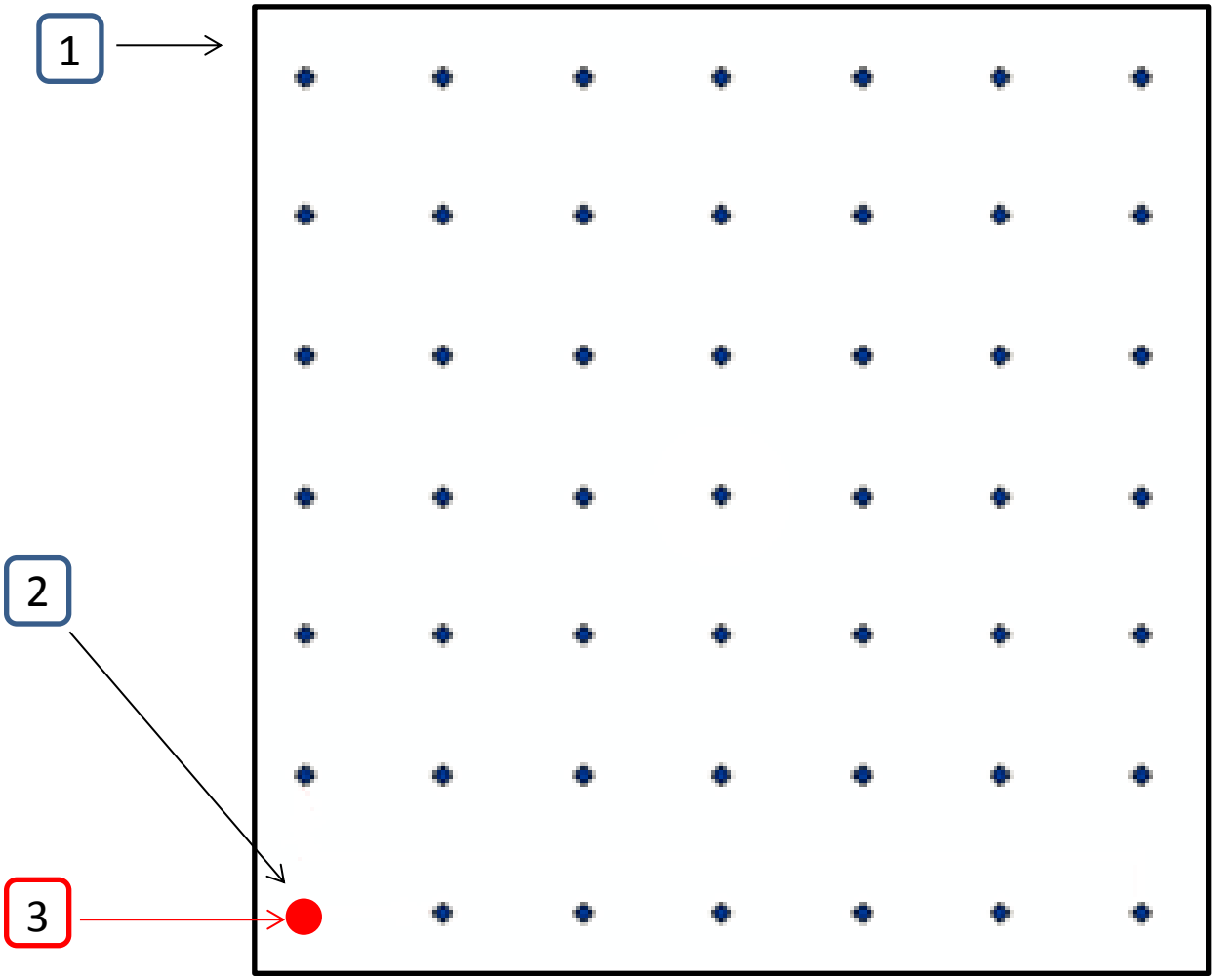
Well Placement Algorithm



Calculating Transmissivity

- Transmissivity is calculated for each cell block.
  - Permeability * Layer Thickness
    - The higher the transmissivity, the more desirable the location for well placement.

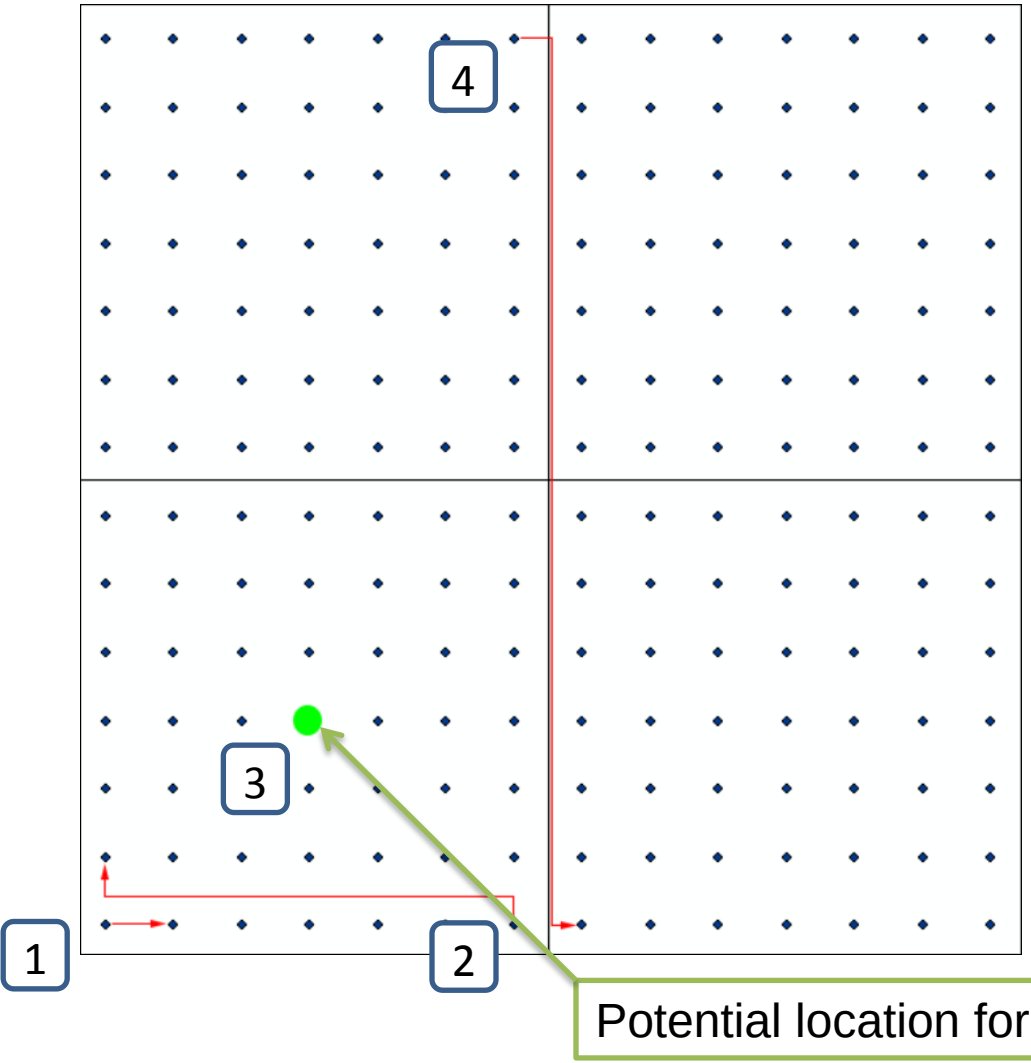
Well: 2 Injectivity of well: 13633.6984873

	Layer Injectivity		Permeability		Cell Thickness	Pressure
Layer 1	3191.433004		174.241000		18.316200	6534.640
Layer 2	54.602973		2.981130		18.316200	6542.570
Layer 3	4618.686257		252.164000		18.316200	6550.510
Layer 4	1481.152334		80.865700		18.316200	6558.440
Layer 5	9.359688		0.511006		18.316200	6566.370
Layer 6	1044.986201	=	57.053500	x	18.315900	6574.300
Layer 7	5.307653		0.289776		18.316400	6582.230
Layer 8	8.978637		0.490210		18.315900	6590.160
Layer 9	7.695837		0.420161		18.316400	6598.090
Layer 10	1.930917		0.105423		18.315900	6606.020
Layer 11	2958.322727		161.514000		18.316200	6613.950
Layer 12	1.565088		0.085448		18.316200	6621.880
Layer 13	146.576123		8.002540		18.316200	6629.810
Layer 14	6.855277		0.374274		18.316200	6637.750
Layer 15	96.245770		5.254680		18.316200	6645.680

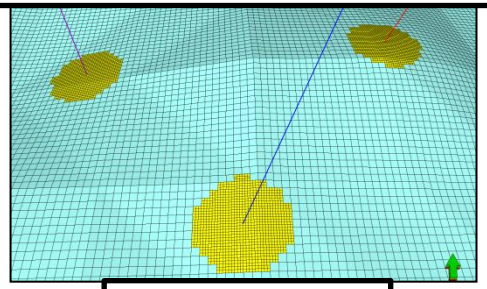
Pressure @ Used Bottom Layer: 6645.68 MD: 14983.72 BHP: 8990.232

Further Applications

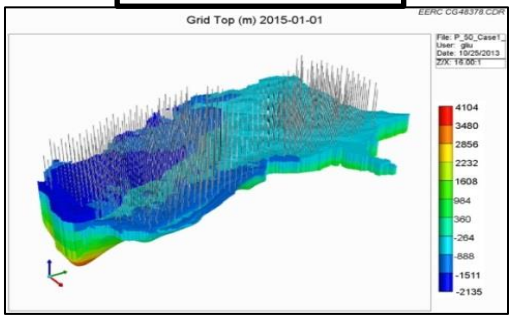
- Advanced algorithm for well placement



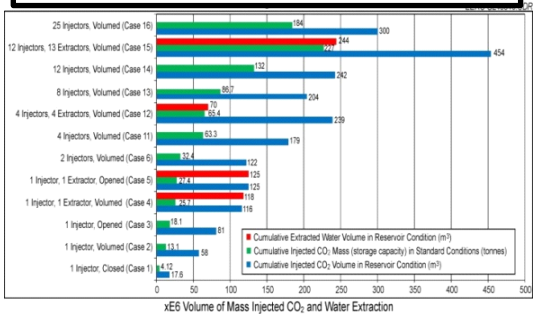
Local Grid Refinement



Simulation



Further optimization



Bottom Hole Pressure Calculation

- Layers from 3-D model in Petrel are transferred to ArcGIS.
  - Data is rasterized.
  - Using a Python script, pressures are computed based on measured depth and a pressure gradient.

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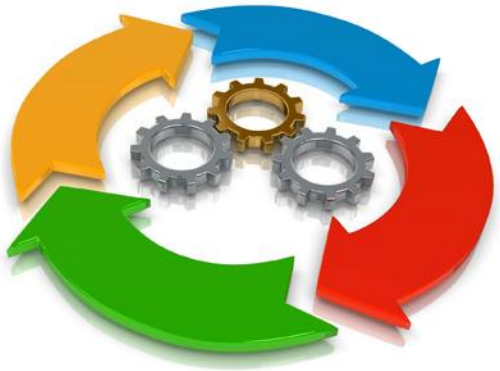
Pressure @ Used Bottom Layer: 6645.68 MD: 14983.72 x .6 = BHP: 8990.232

Overall Summary

- Can use these tools to evaluate data in 2-D and 3-D
  - Plume management, pressure differences, well placement optimizations, horizontal well evaluation, fracture swarms, geologic probability, seismic correlation
- Integrate results from simulation with other decision making tools
- Assist in decision making processes
- Save countless project hours



Contact Information

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

World Wide Web: **www.undeerc.org**
Telephone No. (701) 777-5000
Fax No. (701) 777-5181

Jason Braunberger, Research Manager
jbraunberger@undeerc.org

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